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REPORT ON THE UNITED NATIONS/EUROPEAN SPACE AGENCY TRAINING COURSE FOR LATIN AMERICAN AND CARIBBEAN COUNTRIES ON THE MONITORING OF NATURAL RESOURCES, RENEWABLE SOURCES OF ENERGY AND THE ENVIRONMENT USING DATA FROM THE EUROPEAN REMOTE SENSING SATELLITE

(18-28 April 1994, Frascati, Italy and 29 April 1994, Rome)

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INTRODUCTION

A. Background and objectives

1. At its thirty-seventh session, the General Assembly adopted resolution 37/90 of 10 December 1982, in which it endorsed the recommendation of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) that the United Nations Programme on Space Applications should, inter alia, promote the growth of indigenous nuclei and an autonomous technological base in space technology in developing countries, as well as promote greater cooperation in space science and technology between developed and developing countries as well as among developing countries.

2. The Committee on the Peaceful Uses of Outer Space (COPUOS), at its thirty-sixth session in June 1993, endorsed the activities of the United Nations Programme on Space Applications for 1994 as proposed by the Expert on Space Applications (A/AC.105/555) and as recommended by its Scientific and Technical Subcommittee at its thirtieth session. Subsequently, the General Assembly, in its resolution 48/39 of 10 December 1993, endorsed the activities of the Programme on Space Applications for 1994.

3. In response to Assembly resolution 48/39, and in accordance with the UNISPACE 82 recommendations, the Programme on Space Applications included, as part of its activities for 1994, the organization of a Training Course for Latin American and Caribbean Countries on the Monitoring of Natural Resources, Renewable Sources of Energy and the Environment using Data from the European Remote Sensing Satellite (ERS-1). This Course was the second in a series following a similar one organized in 1993 for the benefit of African Francophone countries (A/AC.105/556/Add.1).

4. The United Nations/European Space Agency Training Course for Latin American and Caribbean Countries on the Monitoring of Natural Resources, Renewable Sources of Energy and the Environment using Data from the European Remote Sensing Satellite (ERS-1) was organized jointly by the Programme on Space Applications, Office for Outer Space Affairs, and by the Department for Development Support and Management Services in cooperation with the European Space Agency (ESA).

5. The objectives of the Course were (a) to provide participants from Latin American and the Caribbean countries with a theoretical basis and practical experience in various aspects of microwave remote sensing, focusing on the applications of that technology to natural resources, sources of renewable energy and, in particular, its use in conducting inventories and monitoring the environment; and (b) to familiarize the participants with the operational services of ERS-1 (e.g. data coverage, data sources and products processing levels), bibliography and archive of ERS-1 materials and data that are available at the European Space Research Institute (ESRIN) facility at Frascati, Italy.

B. Organization and programme of the Course

6. The Course was held from 18 to 28 April 1994 at the ESA/ESRIN facility. The final session and closing ceremony of the Course was held on 29 April 1994 at the Headquarters of the Istituto Italo-Latino Americano (IILA) in Rome. The Course was attended by 24 participants from the following 19 countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela. Financial support to defray the cost of air travel and living expenses of the participants was provided by the United Nations Trust Fund for New and Renewable Sources of Energy. The programme for the Course was developed jointly by ESA and the United Nations (Office for Outer Space Affairs). The lecturers for the Course came from France, Spain, ESA and the United Nations (Office for Outer Space Affairs).

7. The Course provided participants with the physical theory on which remote sensing, both active and passive, is based. The Course presented an overall view of remote sensing in various intervals of the electromagnetic spectrum, including the visible, infrared and microwave regions and highlighted the multidisciplinary nature of the use of the data. Since the ERS-1 payload is composed mostly of active radar instrumentation, the Course emphasized active microwave remote sensing. The Course included the theory and concepts of Synthetic Aperture Radar (SAR) image formation as well as an introduction to digital image processing of radar data in oceanographic, geologic, hydrological, topographic and cartographic applications. The Course also provided the participants with examples of the applications of the data received from various of the instruments on-board ERS-1 as well as with hands-on experience in digital processing of microwave image products. The complementary information that can be obtained from optical and radar data was stressed as a powerful asset for remote sensing. Presentations made by the lecturers included case-studies of programmes or projects conducted in Latin America.

8. The United Nations and ESA utilized the presence of individuals representing institutions from 19 countries in the region of Latin America and the Caribbean to further develop the concept of a programme proposal that could provide satellite data for institutions in developing countries. This concept had originated during the first course held at Frascati in 1993 for African Francophone countries. The concept that was discussed and the work that was conducted by the participants and co-sponsors of the Course are summarized in the section that follows.

9. The present report, which covers the background, objectives and organization of the Course as well as giving a summary of the technical presentations (see annex to this report for the programme of the Course), has been prepared for COPUOS and its Scientific and Technical Subcommittee. The participants in the Course have reported on the knowledge acquired and on the work that they conducted during the Course to the appropriate authorities of the Government, universities and research institutions in their own countries.

I. POSSIBILITIES FOR THE ACQUISITION OF SATELLITE DATA

A. Background

10. Together with satellite systems of other national agencies, the remote sensing satellites (ERS) of ESA contribute to observing the Earth and its environment in a systematic, global and accurate manner. Through modern technology they provide measurements of physical parameters of the ocean-land-atmosphere system with continuity, compatibility and full coverage, night and day. Where supported by operational ground acquisition stations, they ensure long-term observations and therefore they make available time series of consistent and calibrated remote sensing data. This allows the building up of a history of parameters describing a physical phenomenon such as climate. From such a history, characteristics, trends and anomalies of the phenomenon could be identified.

11. Due to the capability of microwave radiation to penetrate clouds, ERS provide all-weather images of the Earth surface and allow the monitoring of surface features even in areas where optical instrumentation fails because of frequent or permanent cloud coverage, such as over equatorial and polar regions. In addition, radar images provide information on surface geometry and humidity which significantly complements surface albedo and temperature data provided by optical satellites, making remote sensing observations a very powerful and versatile tool for applications to environmental disciplines. The nature of such satellite data is in effect multidisciplinary, since they can serve at the same time many applications and different operational requirements. Directly or through ESA services, national institutions may gather this data, archive them and, if required, further process them to serve their users in fields as diverse as geology, oceanography, hydrology, meteorology, glaciology, forestry, agriculture, topography, cartography, land use and environmental fields spanning from urban settlement to pollution monitoring.

12. During the Course held in Frascati in 1993, the participants indicated that two obstacles to their utilization of image products, such as those they had learned to use at the Course, were the lack of access to them and a need for further education on the principles of their use along with hands-on training to develop experience in the mechanics of their analysis. The representatives of the Secretariat and ESA had indicated that they would explore ways and means through which at least a limited amount of data and further training could be provided for use in the ongoing activities of the participants.

13. Between May 1993 and April 1994, representatives of the Office for Outer Space Affairs, Department of Development Support and Management Service of the United Nations and ESA discussed the issue and concluded that (a) for the courses to reach their objectives fully, it was essential that participants in the Training Course on their return home should have access to satellite data and to the necessary image processing software in order to strengthen their newly acquired skills; (b) institutions with ongoing projects would be the most likely to need and utilize the data; and (c) a programme proposal could be developed by the co-sponsors for capacity building and institution strengthening through which a limited amount of data, necessary software and further training could be provided to some institutions in the developing countries.

14. The development of the programme would include the following three phases: (a) needs assessment to determine the degree of interest of institutions in the regions participating in the programme and the quantities and types of data needed; (b) identification of ongoing projects in Africa and in Latin America and the Caribbean that are using or could use satellite data; and (c) selection of projects on the basis of those remote sensing applications that were in greatest demand in the regions concerned. Subsequently, the programme would be presented by the co-sponsors, with the endorsement of the institutions and their Governments, to potential funding sources. The data that the programme would provide would not be limited to ERS-1 data but, on the basis of the requirements of the projects, could be from other satellites (e.g. LANDSAT, SPOT) or from a combination of them in order to take advantage of the complementary nature of satellite-obtained data.

B. Preparatory work conducted by participants

15. The above-mentioned concept was presented to the participants in the 1994 Course in Frascati along with an invitation to contribute to the first two phases of the programme. The participants expressed great interest in the offer and decided to invest time after the conclusion of each day's meeting to conduct a survey among themselves on the issues related to phases (a) and (b) described above. The United Nations and ESA provided additional information and assisted the participants in their work.

16. At the conclusion of the Course, a meeting was held at the headquarters of IILA in Rome, attended by representatives of the embassies in Rome of the countries of the participants, at which the participants presented their findings, as follows:

(a) Very few institutions have radar images and even fewer have personnel with a working knowledge of their use. In some cases the images exist at institutions but the software to process them is not available;

(b) Radar images are sources of new and useful information, particularly for tropical areas which are frequently covered by clouds. However, their potential is better utilized when combined with images obtained by the optical-infrared sensor systems on board satellites such as LANDSAT or SPOT;

(c) Projects in nine thematic areas are being conducted by the institutions represented by participants at the Course. These areas are geology, agriculture, oceanography, glaciology, hydrology, geodesy and geodynamics, risk of natural disasters, meteorology and development of software to process radar data;

(d) Participants identified 42 areas located in 18 countries of Latin America and the Caribbean where institutions from at least three countries have ongoing projects in application areas with similar objectives.

The participants provided a copy of this report to the co-sponsors.

17. The United Nations and ESA informed the participants that the co-sponsors would conduct a complementary needs assessment campaign for the region as a preparatory phase to preparing the programme proposal referred to above. The co-sponsors would keep the participants and their institutions informed on the progress that was made.

II. SUMMARY OF PRESENTATIONS

A. Fundamentals of remote sensing

18. Electromagnetic radiation incident on an object on the surface of the Earth interacts at the atomic and molecular level with the object. The portion of radiation that is reflected in the direction of a remotely placed sensor carries information that is intrinsic to the object. In remote sensing applications, the challenge is to identify the object given a measure of the relative amount of radiation that it has reflected. Discrimination between diverse types of objects becomes easier if measurements are done in several regions of the electromagnetic (EM) spectrum. The regions of the EM spectrum where these remote measurements are done are called "spectral bands" or simply "bands".

19. Photographic film is a sensor of electromagnetic radiation. It has been designed to represent objects approximately as they appear to the human eye in everyday situations. That is, photographic film is sensitive to radiation in the visible portion of the EM spectrum. The simplest and most inexpensive remote sensing product that can be obtained is a photographic representation of the image acquired by any type of sensor system. Such representations are generated for all sensor systems whose data have been acquired at any of a number of intervals of the EM spectrum.

20. A distinction has purposely been made in using the term "image" when referring to a representation of objects produced by a sensor which is not photographic film. Different types of sensors are used to extend detection capabilities to regions of the EM spectrum where photographic film does not respond. The type of sensors used in these regions are solid state detectors sensitive to EM radiation in specific wavelength intervals which may or may not include the visible region. In response to radiation received, detectors generate either a voltage or a current that is proportional to the amount of radiation received in their wavelength band of operation. The output signal is electronically sampled and converted to digital values that maintain a one-to-one correspondence to the original voltage or current value.

21. The digital values are stored on board the satellite for transmission to a ground receiving station. The digital data are corrected for geometric and radiometric distortions and arranged in matrix form, where each element of the matrix corresponds to the radiation received by the sensor from each resolution cell on the surface of the Earth. With the data in this form, it is possible to perform a computer-assisted analysis of the image. In order for the user to visualize the image, its range of digital values is first normalized to fall with values from 0 to 255. A correspondence is then established between those digital values and a scale of grey tones going from black to white. This makes it possible for the image to be displayed, either on a screen monitor or on photographic film, in tones of grey.

22. Since an image is only a visual representation of the data obtained by the sensor system, its appearance can be arbitrarily modified. When data from only one band is displayed, it can be done in tones of grey or

in hues of one of the primary colours (i.e. blue, green or red). If more than one band is to be displayed at the same time, each is assigned to hues of a primary colour (i.e. blue, green or red) and the user can select whether to display one, two or three bands simultaneously. Objects on the surface of the Earth appear in colours, which are a result of the superposition of the hues of the primary colours which in turn are a representation of the relative amount of EM radiation reflected by the objects in the intervals of the EM spectrum that correspond to the bands being displayed.

B. Digital image processing

23. The large potential that remote sensing from space offers is due to the following main characteristics: (a) the large surface area covered by each image; and (b) the high frequency with which data can be gathered over the same area. Once acquired, the data are only useful after an analysis has been performed to extract information from them. That is, the features that are being studied must be identified and quantified. This process is called photointerpretation when performed through visual inspection of the image. The same process is called classification when performed with the aid of a computer. In both cases the objective is the same: to identify classes of objects and to discriminate between those that are of interest to the study and those that are not.

24. The use of computers can enhance and speed the process of extracting the information. The information contained in the images is originally in digital form to facilitate its display and analysis with a computer-based image processing system. However, excellent results can be obtained from interpretation of photographic representations of the area being studied. A large number of examples of quality work using photointerpretation exist, particularly in applications such as forest management and geological mapping. At present it is possible to purchase high-quality photographic negatives or black and white/colour prints or transparencies of images at scales of up to 1:50,000. These photographic products are inexpensive and their interpretation requires simple equipment which is readily available in universities and survey and mapping institutions.

25. Digital image enhancement techniques improve the visual presentation of the information content of an image. These techniques assist in visual interpretation but do not create any new information. Common techniques include the following: contrast enhancement, spatial filtering, linear combinations of bands and principal component transformations. This step is usually done to allow the user to better identify a few areas or test fields in the image that can be used to "train" the computer during the classification process as well as to evaluate the results obtained from a classification. In the best of cases, the user has complete knowledge of the objects present on the ground in the test fields and can relate the digital values on the image to corresponding objects in the test fields.

26. Software programs which are used to discriminate the elements present in an image are called "classifiers" and fall into two broad categories, which are defined by the degree of intervention necessary by the user. The most commonly used programs are the so-called "supervised classifiers". For these, the user identifies homogeneous test fields that are representative of the classes of objects in the image. For one of the bands, the classifier calculates the mean and standard deviation of the digital values of the picture elements (pixels) in each test field. This process is repeated for each of the spectral bands included by the user in the classification process.

27. The set of values of the mean and standard deviation of a class in each of the spectral bands used become the parameters that are used to identify the pixels that belong to a particular class. This set of values is also known as the "spectral signature" of the class. When the spectral signatures of all the important classes in the image have been obtained, the program classifies every pixel in the image as belonging to one of those classes. Pixels whose spectral signatures do not match any of the ones provided are usually assigned to a catch-all class ("other"). If the evaluation of the results is not satisfactory, the user must repeat the

process by redefining the test fields and adding or removing classes. The process becomes iterative until the degree of accuracy is achieved.

28. Unsupervised classifiers require little interaction by the user and are based entirely on mathematical and statistical methods. While this approach makes the classification independent of specific knowledge of the area by the user, it is highly dependent on the mathematical and statistical skills of the user. In addition, unsupervised classifiers use very little of the general experience accumulated by the user in a specific field of application. Regardless of which method is used to classify satellite images, the information that is extracted is hardly ever used by itself but rather to complement or supplement information available from other sources as well as to reduce the amount of field work necessary to achieve the goals of a project.

C. Earth observation satellite systems

29. Earth observation satellites are classified as being "polar orbiting" or "geostationary orbiting" satellites. Together they form a family of satellites that cover practically all areas of the Earth (except for small regions around the poles), in a broad range of bands of the electromagnetic spectrum and with a diversity of spatial and spectral resolutions. Polar orbiting satellites are placed in low-Earth orbit a few degrees off of the poles and are Sun-synchronous (overhead passes at the same local solar time). These satellites have high spatial and spectral resolutions and long revisiting periods (on the order of days). Geostationary satellites are placed in high orbit (36,000 km) above the Earth's equator. In this particular orbit, called the geostationary orbit, the satellites rotate at the same angular velocity as the Earth so that they appear to remain stationary over the same area of the Earth. Geostationary satellites have a very high revisiting period (up to every half-hour) but their sensors have low spatial and spectral resolutions.

30. Very important geostationary satellites are the meteorological satellites (METEOSAT, GOES I and II, GMS and INSAT). These satellites are operated by a European consortium, EUMETSAT, by the National Oceanographic and Atmospheric Administration (NOAA) of the United States of America, by the Japan Meteorological Agency and by the Indian Space Research Organization and are coordinated by the World Meteorological Organization. The primary function of these satellites is to provide data for studies of meteorological phenomena, to warn of catastrophic events and to forecast weather.

31. Meteorological satellites are also placed in polar orbit from where they provide north-south coverage of the Earth. These satellites have medium spatial and spectral resolutions; higher than satellites placed in the geostationary orbit but lower than satellites that are conventionally called Earth resources satellites. Polar orbiting satellites include the NOAA/TIROS-N series, the METEOR-2 and -3 series, operated by the Russian Federation, and the FENG YUN-1, operated by China. The primary function of these satellites is also meteorological. Operational products from these satellites include rainfall estimates, hurricane classification, tropical storm bulletins, cloud-top height and cloud motion (winds) data. Data from these satellites are also being used for large-scale agriculture, oceanography and water management.

32. However, increasingly the data of polar orbiting meteorological satellites have been used for monitoring land phenomena such as the advance of desertification at regional and global scales. An instrument that has been extensively used in such studies is the NOAA Advanced Very High Resolution Radiometer (AVHRR). AVHRR is a five-spectral band scanning radiometer which provides imagery (i.e. quantitative radiance data) at both 1 km and 4 km resolutions. The data are broadcast in real time to both Automatic Picture Transmission (low resolution) and High Resolution Picture Transmission (HRPT) users. Data from AVHRR can also be recorded on board for eventual transmission when the satellite is not within the line of sight of a ground receiving station.

33. The five spectral bands of the AVHRR sensor and the applications in which they are typically used are the following:

Band 1	0.58-0.68 micrometers	Daytime clouds, snow and ice mapping.
Band 2	0.72-1.10 micrometers	Surface water delineation, vegetation and agriculture assessment.
Band 3	3.55-3.93 micrometers	Night-time cloud mapping, sea surface temperature measurement, hot spot detection (e.g. forest fires).
Band 4	10.3-11.3 micrometers	Day/night cloud mapping, sea/land surface temperature, soil moisture volcanic eruptions.
Band 5	11.5-12.5 micrometers	Sea surface temperature and soil moisture.

A linear combination of bands 1 and 2 is commonly used for vegetation index studies, in particular to monitor the advance of deserts.

34. Earth resources satellites are placed in low, nearly polar orbit and provide high spatial resolution. This resolution is typically in the range of 10-30 m and is likely to improve to 1-2 metres by the year 2000. Earth resources satellites have long revisiting periods (of the order of weeks) and cover swaths of the order of 100 km in width. Operational satellite systems in this category include SPOT-2 and -3, LANDSAT-5 and IRS-1. Sensors on board these satellites operate in the visible and near infrared parts of the EM spectrum. The products from these satellites are distributed commercially by private enterprise; in the case of SPOT, the data are distributed by SPOT Image and in the case of LANDSAT and IRS, their data are distributed by EOSAT.

35. The data from the Earth resources satellites have been progressively used in many and diverse applications since the first LANDSAT satellite was launched in 1972. Since then, the data have been used with increasing success in the following main areas:

(a) Agriculture and forestry: discrimination of crop, timber and range vegetation types, determination of crop acreage by species, timber acreage and volume by species, range biomass, vegetation vigour and stress, determination of soil conditions and associations, and assessment of damage to grasslands and forests by fire;

(b) Land-use and land mapping: classification of land uses, cartographic mapping, categorization of land capability, separation of urban and rural areas, regional planning, and mapping of land/water boundaries and transportation networks;

(c) Geology: mapping of major geologic units, igneous intrusions and recent volcanic deposits, recognition of rock types, search for surface indications of mineralization and determination of regional structures;

(d) Water resources: determination of surface-water area and volume, mapping of floods and plains, determination of snow and ice areas and boundaries, sediment and turbidity patterns including water depth and delineation of irrigated fields;

(e) Oceanography and marine resources: detection of living marine organisms, of turbidity and circulation patterns, mapping of shorelines, shoals, shallow areas and their changes, mapping of ice for shipping routes and studies on global phenomena such as El Niño;

(f) Environment: mapping and monitoring of land, air and water pollution, surface mining effects, determination of natural and man-made desertification, deforestation, eutrophication, and impact of urban and large infrastructure development.

36. Two other operational systems carry on board a combination of visible, infrared and microwave (radar) sensors. These two systems (ERS-1 and JERS-1) are operated by the European Space Agency and by the National Space Development Agency of Japan.

D. Concepts of radar remote sensing

37. Sensors that operate in the visible and infrared portions of the EM spectrum detect reflected sunlight or emitted thermal radiation and are not well suited to some types of Earth observation. This is particularly the case for tropical areas, which for large periods of time are not visible due to their cloud cover. In other situations, it may be necessary or desirable to view a region of the Earth as frequently as possible. For such cases it would be convenient to have the capability of observing the region of interest during periods in both the day and the night.

38. Microwave radiation, either emitted by the Earth due to its black body radiation characteristics or reflected from an external source such as the Sun, can penetrate cloud cover and even light rain and can also be measured during the night. There are two types of sensors that detect this radiation. These sensors are grouped into "passive" and "active" sensors depending on whether they detect radiation emitted or reflected from a natural source or whether they detect radiation that has been generated by the instrument itself.

39. Satellites that carry a radar sensor instrument on board (called radar satellites) provide their own "illuminating" source and are thus not dependent on sunlight. (The term "radar" stands for radio detection and ranging.) A radar instrument transmits short electromagnetic pulses that are backscattered by the surface of the Earth and that penetrate cloud cover with little or no attenuation. The backscattered radiation is received at the satellite and converted into an electrical signal that is suitable for recording and subsequent transmission to a ground receiving station. Radar satellites can have both imaging and ranging systems on board.

40. The main quantities that are measured by a radar instrument are (a) the time delay of the reflected signal; and (b) the intensity of the reflected signal. The first of these quantities provides the direction and distance of an object to the radar while the latter provides the orientation, geometry, roughness and dielectric properties of the object. The roughness of an object is a characteristic that depends on the wavelength of the incident radiation. If the characteristic dimension of the object is small compared to the wavelength of the incident radiation, the object is considered smooth. If the characteristic dimension of the object is approximately the same as the wavelength of the incident radiation, the object is considered rough.

41. For remote sensing purposes, an imaging radar system is carried on board an aircraft or satellite. The system consists of a transmitter, a receiver, an antenna which transmits and receives EM radiation, and a signal processing and recording unit. The transmitter generates short microwave pulses of radiation with duration of microseconds each. The pulse is transmitted by the antenna in a narrow beam into the range direction. For imaging radar systems, the geometric configuration is such that the beam is radiated from the side of the satellite at some angle of incidence to the surface of the Earth and perpendicular to the flight direction. This is called a Side Looking Airborne Radar (SLAR). More sophisticated versions of airborne radar have the same geometric configuration but utilize the concept of simulating a longer antenna by taking advantage of the motion of the satellite or aircraft and a complex sampling procedure of the returned signal. This type of instrument is called a SAR.

42. The reflected portion of the transmitted pulse is collected by the antenna and the instrument determines both the strength of the returned signal and the time delay with respect to the transmitted pulse in order to determine the range distance of the sensed object relative to the satellite. The radar beam is wide in the vertical direction and narrow in the horizontal or along-track direction. The motion of the satellite produces a two-dimensional image plane which results in a parallel and oblique view of strips of the surface of the Earth. This makes the scanning concept of an imaging radar very different from scanners that operate in the visible and infrared regions of the EM spectrum. The latter build an image of the surface of the Earth on a line-by-line basis, their viewing geometry is downward-looking and the spatial resolution of the resulting images depends on the angular resolution of the system's optics and on the altitude of the satellite or aircraft.

43. An imaging radar system has two spatial resolutions: one in the range or across-track direction and one in the along-track or azimuth direction. These resolutions depend, first on the electronic characteristics of the instrument and secondly on the geometry of the radiation incident on the surface. In the case of a SLAR, the azimuth resolution increases with increasing length of the antenna but decreases when objects are farther away from the antenna. The range resolution is determined by measuring the time delays along the slant path between reflected signals from the objects back to the antenna and increases as the time delay between transmitted and reflected pulses is shorter. For equal time delays (i.e. slant path resolution), ground resolution is better of objects farther away from the antenna.

44. For a SAR instrument, the limiting factor for their range resolution is being able to shorten the transmitted pulse while maintaining sufficient power to detect the reflected signal. A SAR system maintains the range resolution by transmitting more energy through a technique known as "chirping" whereby the transmitted pulse is modulated by a signal whose frequency increases (or decreases) linearly in time instead of through a sinusoidal modulation. Through a Doppler effect analysis of the reflected signals, the motion of the radar platform is used to improve the azimuth resolution and to make it independent of the distance of the object to the antenna and of the frequency of the incident radiation. This results in a constant resolution in the azimuth direction which is much better than that in the case of a SLAR.

45. In radar image formation, the first return pulse corresponds to the object whose projected distance in the direction of the sensor system is the smallest. In general, this pulse corresponds to the object closest to the flight path. Because of the geometry of the incident pulse and the height of objects, the projected distance in the direction of the sensor system of the upper part of an object is smaller than the distance of its corresponding ground projection. This effect is known as foreshortening and makes terrain of high relief appear in the image as falling towards the radar. On the images, foreshortening causes the slopes to become extended and to appear darker. This effect can be corrected with reference to a digital terrain map.

46. The foreshortening effect can become very severe so that the top of a mountain appears to be closer to the flight path than the foot of the mountain. This effect is called layover and cannot be corrected. Other image degradations include speckle effect - which appears as a noise on the image although strictly speaking it is not and is related to the frequency coherence of the system - as well as several effects due to the motion of the object with respect to the sensor or to other objects in the field of view of the radar.

47. The microwave spectrum is subdivided into various bands, each of which is referred to by a single letter and is determined by a range of frequencies as follows:

Band name	Band interval (GHz)	Band name	Band interval (GHz)
P-Band	0.225-0.390	K-Band	10.90-36.00
L-Band	0.390-1.550	Q-Band	36.00-46.00
S-Band	1.550-4.200	V-Band	46.00-56.00
C-Band	4.200-5.750	W-Band	56.00-100.0
X-Band	5.750-10.90		

For airborne radar missions, the most used bands have been the X-Band, L-Band and K-Band. For the satellite radar systems, current and those to be launched by the turn of the century, the predominant frequency is C-Band.

E. Sources of satellite radar data

48. The European Remote Sensing Satellite-1 (ERS-1) was launched in July 1991 and carries several microwave sensors on board. Its primary instrument is the Active Microwave Instrument (AMI), which can provide high-resolution images (in C-band), wind speed through ocean wave spectra analyses and the length and direction of waves. While in an imaging mode, AMI covers a swath of 80-100 kilometres, with a resolution to the order of 27 metres in the range direction and 29 metres in the azimuth direction.

49. Operating in the wind mode, AMI covers a swath of 400-500 km over the ocean with resolution cells of 50 km and measures wind speed in the range of from 4 to 24 m/s with an accuracy of from 0.5 m/s to 2 m/s. Wind speed and direction are determined by measuring the strength of the backscattered signal of each resolution element from three directions: obliquely ahead, to the side and obliquely behind the satellite path. The intensity of the three signals provides the wind speed, and the differences between them indicate the wind direction with an accuracy of 20°. In wave mode operation, AMI determines the length and direction of ocean waves in 5 x 5 km cells for segments of 200-300 km along the satellite path. Ocean wave lengths of 100-1,000 m can be measured to an accuracy of 25 per cent.

50. ERS-1 also carries a Radar Altimeter (RA) that operates on a wavelength of 2 cm. This altimeter is used to measure average wave height, wind speed and to determine meso-scale ocean topography. Data from this altimeter have been used successfully to determine ice type and topography as well as the water/ice boundaries.

51. A third instrument on board ERS-1 is the Along Track Scanning Radiometer (ATSR) that operates in three bands in the thermal region of the EM spectrum. These bands are centred at 3.7, 11 and 12 micrometers. ATRS looks through the atmosphere at the surface of the ocean from two directions, downwards vertically and at an incidence angle of 50°. The difference between the oblique and vertical measures provides information on atmospheric absorption while the differences between measurements at the three wavelengths are used to determine atmospheric water vapour content.

52. The three instruments described above were designed primarily for ocean observations. Of the three, AMI, in its imaging mode, has been finding the greatest number of applications for land monitoring, surveying and exploration. In particular, its SAR images have been tested, with varying degrees of success, in agriculture, forestry, hydrology, cartography, geology and for monitoring natural hazards such as floods and mud-flows. Near the coastline, SAR images have found applications to aquaculture, mangrove forestry and coastal monitoring (coastline, erosion, tidal flows and effects of dams).

53. Launched in 1992, the Japanese Earth Resources Satellite (JERS-1) is also equipped with a SAR sensor. However, this sensor system operates in the L-Band (0.390-1.550 GHz). JERS also carries a Visible and Near Infrared Radiometer (VNIR) and a Short Wavelength Infrared Radiometer (SWIR); both instruments provide a spatial resolution of 18 m x 24 m. This satellite is equipped with an on-board recorder for transmission of gathered data when it comes within the line of sight of one of its ground receiving stations. The revisiting period for this satellite is 44 days.

54. JERS-1 has been placed in Sun-synchronous orbit and its data is received by the Hatoyama Observation Center and by several other receiving stations around the world. This satellite conducts a variety of observations, not only for resources exploration but also for land survey; agriculture, forestry and fishery; sea-ice monitoring; environmental monitoring; disaster prevention; coastal monitoring; and other applications.

F. Calibration and validation of image products

55. Microwave techniques involve sophisticated processing of the return signals to derive geophysical parameters. The calibration of the instruments and long-term verification of geophysical measurements are therefore vital components of a reliable system. Thus, radar systems are periodically calibrated using ground-based artificial targets including specially designed transponders.

56. The radiometric calibration of a SAR system can establish a relationship between the intensities of an image (the numerical values of the pixels) and the backscattering coefficient of the surface being viewed. The relative calibration of a SAR makes it possible to determine the precision of a measurement compared to another measurement made on images acquired on different dates. The absolute calibration of a SAR makes it possible to determine the absolute precision of a measurement; that is, the difference between the measured value of the backscatter coefficient and its real value. This type of calibration takes into account internal factors of the instrument such as the gain settings of the instrument and of the processors.

57. For validation of the reliability of the products, the ultimate test is a direct comparison of derived estimates of geophysical parameters with the real values. Validation checks are regularly conducted to compare radar-derived estimates of surface winds and waves against actual sea surface measurements. Similar checks are conducted to determine the accuracy of the radar altimeter and of the imaging mode of the instrument.

58. For validation of ERS-1 products, the parameters that determine the quality of the images, and that are carefully controlled, are the following: (a) spatial resolution, (b) radiometric resolution, (c) radiometric calibration (relative and absolute), (d) geometric calibration and (e) phase characteristics. The treatment of parameters in the processing stage makes the appropriate radiometric corrections (taking into account the radiation pattern of the antenna) and takes into account the gain settings of the processors, verifies the linearity of the settings and utilizes adequate normalization methods. The annotations of the quality of the product, including information on calibration, are included in the format of the computer compatible tapes (CCTs) or on the photographic reproductions.

G. Radar applications to agriculture and forestry

59. The general objective of the use of remote sensing in soil, agriculture and forestry applications is to obtain information for resources inventory and management or for understanding environmental and global change phenomena. The use of radar images can complement existing information or that which might be acquired by other sensors including field data. In this sense, radar can make important contributions to: (a) identification and mapping of vegetation and soil types; (b) determination of phenological stages, deforestation, afforestation, regrowth and desertification; and (c) extraction of biophysical parameters such as biomass, vegetation density, and height and soil moisture.

60. Microwave techniques for measuring soil moisture include the use of both passive and active sensors with each having distinct advantages. Passive microwave techniques have a large area coverage since the source of the radiation is emission from the Earth itself while active systems measure only radiation reflected from the swath within the beam that has been sent by their antenna. However, active systems provide more power to the signal and can achieve higher resolutions. In addition, the choice of incidence angle of the radiation, its wavelength and polarization allows for such possibilities as gathering information from the crown of a forest or for a far greater penetration of the vegetation canopy.

61. The theoretical basis for measuring soil moisture using either active or passive microwave sensors is based on the large contrast between the dielectric properties of water and dry soil. The dielectric constant for water is of the order of 80 while for dry soils it is between 3 and 5. As a result, as water is added to soil,

the dielectric constant of the combination can change dramatically. The magnitude of both emitted and reflected microwave is dependent on the value and changes of the dielectric constant. Thus, changes in measured values in the microwave region of the EM spectrum can be directly related to degrees of soil moisture. In recent experimental results, radar backscatter responses extracted from ERS-1 SAR data have been strongly correlated to soil moisture content.

62. In contrast to water or soil/rock surfaces which have a continuous interface with air, vegetation has a discontinuous or not well-defined interface (e.g. a surface covered by leaves and air spaces). The strength of the backscattered signal can result from surface scattering (continuous interface), volume scattering (i.e. from the entire canopy) or multiple surface-volume scattering interactions. Thus, the penetration of the incident radiation, the surface roughness of the vegetation and the dielectric properties of the volume all contribute to the net backscattered radiation detected by the SAR antenna. The effects of these parameters on the measured signal depend on the angle of incidence, polarization and frequency of the radiation, and a careful consideration (or selection) of their characteristics is necessary to arrive at an accurate analysis of SAR data.

63. Incident microwave radiation of lower frequencies (i.e. longer wavelengths) penetrates vegetation more and returns information on the structure of the canopy including the trunks/stalks and possibly the soil boundary. This information is best extracted through elaborate canopy modelling techniques that perform a mathematical treatment of the physical interaction of the radiation with each class of component (leaf, trunks/stalks, soil). However, simpler analyses leading to a determination of whether the dielectric constant of the area under observation is closer to the values expected for soil than for vegetation can serve to separate sparse vegetation (low plant density and height) from dense vegetation as would be the case for various growth stages of crops. If the microwave wavelength is chosen to interact with the leaf portion of the canopy, the vegetation volumetric water content will also serve to indicate an advanced growth stage. The same technique could be used to delineate flooded from non-flooded vegetation. In the latter case, the vegetation cover might be so dense that the effect of the underlying water does not appear in the visible or infrared bands.

64. The delineation of forest and non-forest areas is generally possible in SAR images. Good results have been obtained in identifying swamp forest stands. However, the discrimination of forest clearcut and regeneration sites has been generally poor when images from only a single date or taken in a single frequency band have been used. A significant improvement has been noted when either a multi-temporal or a multi-frequency approach has been used taking advantage of change detection information. Deciduous and coniferous stands can be differentiated by the use of multiple view angles.

H. Use of radar in geology

65. Radar images have been used by geologists for more than 20 years for lineament detection and mapping as well as for oil and mineral exploration. The use of SAR images in these fields has been natural because the interaction of the radiation is to a large degree with the object of interest. That is, the rock and terrain are often exposed and not obscured by vegetation or other matter that could mask their effect on the returned signal. In addition, radar images are particularly sensitive to topographic features, surface roughness and moisture content (or to the lack of it).

66. In the case of lineament studies, the interpretation of images is done in a similar manner to the procedure used with conventional air photographs. However, the interpreter should bear in mind that the shadows seen on the image are due to the oblique incidence angle of the microwave radiation and not to solar illumination. Thus, associated effects that need to be considered are foreshortening and layover; these effects have been previously described. However, the use of images obtained at different view angles has been

found to enhance the shadow effects with the end result that they facilitate the recognition of lineaments over mountainous regions.

67. Topography enhancement is also related to the incidence view angle selected and improved results have been obtained from the analysis of several images acquired with different viewing angles. Since in general, the drainage network appears clearly on SAR images, its combined use with the topography (also derived from the SAR image) allows for a satisfactory study of the geomorphology of the area. Because of the penetrating capabilities of microwave radiation, there are examples where even subsurface structure which is part of a drainage network can be seen beneath sand-covered plains.

I. Radar altimetry for oceanography

68. The ERS-1 radar altimeter is a Ku-Band (13.8 GHz) nadir-pointing instrument designed to measure the time return echoes from ocean and ice surfaces. Functioning in one of two operational modes (ocean or ice) the altimeter provides information on significant wave height (SWH), surface wind speed, sea surface elevation (which relates to ocean currents, the surface geoid and tides) and on various parameters over ice.

69. The radar altimeter operates by timing the two-way delay for a short duration pulse that is transmitted vertically downwards. To reach the desired level of accuracy in range measurements (better than 10 cm from satellite altitude), the pulse is transmitted using the "chirping" technique mentioned above.

70. The altimeter has been designed to meet the following objectives:

(a) Global measurements of the height of the ocean waves (SWH): such measurements are very important to marine users and scientists trying to understand the ocean's dynamic behaviour. The altimeter provides data over vast regions of the oceans that did not have regular observation;

(b) Measurement of the satellite's height above the local mean sea surface: this application is used for the operational monitoring of the boundaries of major ocean currents, an activity that has significant economic benefits;

(c) Global measurements of wind speed: these values complement the wind field measurements by the AMI instrument and are used to distinguish swell from wind-driven waves;

(d) Long-term monitoring of the topography of ice sheets to provide vital warning capability for any substantial change in the Earth's climate.

71. The principle behind the functioning of the altimeter is that the information required is contained in the shape and timing of the returned radar pulse. As the incident pulse interacts with the surface of the ocean, the "illuminated" area grows rapidly from a point to a disk as does the returned power. Eventually, an annulus is formed and the geometry is such that the annulus area remains constant as its diameter increases. The returned signal strength, which depends on the reflecting area, grows rapidly until the annulus is formed and remains constant until the annulus reaches the edge of the radar beam, at which point it starts to diminish.

72. Irregularities on the surface, larger than the pulse width, cause the returned pulse to be distorted and stretched. The effect of this is to impose an additional slope on the leading edge of the returned signal strength curve. This slope is related to the ocean wave height and the mid-point of this leading edge slope is equivalent to the reflection received by the antenna of the average position of the ocean surface.

J. Use of radar to determine wind speed

73. A radar instrument can also be used to determine wind speed and direction. Through the coverage of large areas and the motion of the satellite it is possible to determine wind fields over substantially larger areas. The purpose of the wind scatterometer is to obtain information on wind speed and direction at the sea surface for incorporation into models, global statistics and climatological data sets. It operates by recording the change in radar reflectivity of the sea due to the perturbations of small ripples by the wind close to the surface. This is possible because the radar backscattered radiation returned to the satellite is modified by the wind-driven ripples on the ocean surface. Since the energy in these ripples increases with wind velocity, the signal due to the backscattered radiation also increases with wind velocity.

74. Three antennas generate radar beams that look at 45° forwards, sideways and at 45° backward with respect to the satellite's flight direction. These beams continuously illuminate a swath that is 500 km wide as the satellite moves along its orbit. Thus, three backscatter measurements of each grid point are obtained at different viewing angles and separated by a short time delay. These triplets are input into a mathematical model to calculate surface wind speed and direction.

K. Practical exercises and field trips

75. The participants in the course had several sessions of hands-on training with images from ERS-1, LANDSAT and SPOT. These practical exercises were conducted primarily on PC-based digital image processing systems. Through these practical sessions, the participants became familiar with the type of software programs that are used to perform enhancement and filtering operations on digital images. They also acquired experience in interpreting SAR images for geological, oceanographic and agricultural applications.

76. As part of the preparation for their two field trips, the participants were provided with copies of maps and images of the areas that were to be covered. Explanations of the type of terrain that would be covered and salient features to look for were also given to the participants in preparation for the trips. The instructors of the course participated in the field trips and explained why certain features that were being observed in situ appeared in a particular manner on the images.

III. CONCLUSIONS

77. During the concluding part of the Course, the participants expressed their commitment to follow-up on the work that they had conducted regarding the programme proposal that would be prepared by the United Nations and ESA. In this respect, the participants would inform the authorities of their institutions and would transmit to the co-sponsors a brief overview of the objectives and current status of their ongoing projects. The overview would include specific details on the type and quantity of satellite data that was needed.

78. The participants expressed their appreciation of the technical quality of the training programme that was prepared and delivered to them. In addition, the participants expressed their appreciation for the fellowships received from the co-sponsors, which had made their participation in the Course possible, as well as for the cooperation and support that they had received from administrative and technical personnel of ESRIN.

27 April 1994

	Application to oceanography and near-coastal areas	
09.00-10.45	Radar altimeter data for oceanography	J. Benveniste, ESA
11.15-13.15	Wind scatterometry	P. Lecomte, ESA
14.15-15.30	SAR image and wave spectrum information wind and wave models	M. Fea, E. Oriol, ESA
16.00-17.15	Practical exercises	M. Fea, J. Lichtenneger, ESA

28 April 1994

	Applications to hydrology, sea ice and glaciology	
09.00-12.30	SAR applications	M. Fea, J. Lichtenneger, ESA
12.30-13.15	Radar altimeter and scatterometer data	M. Fea, ESA
14.15-17.15	Presentation of projects	Participants

29 April 1994

09.00-10.30	Travel to IILA in Rome	Co-sponsors
10.30-13.00	Welcome to IILA Statements by authorities	
	General discussion and presentation of ongoing projects in Latin America and the Caribbean	Participants
	Certificates and closing	United Nations/ESA
14.30-16.00	Visit to the IILA exhibit	IILA

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COMMITTEE ON THE PEACEFUL
USES OF OUTER SPACE

REPORT OF THE UNITED NATIONS EXPERT ON SPACE APPLICATIONS

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INTRODUCTION

1. At its thirty-first session, held in Vienna from 21 February to 4 March 1994, the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space (COPUOS) reviewed the activities of the United Nations Programme on Space Applications. The Subcommittee noted that the 1993 activities of the Programme had been carried out satisfactorily, and that the activities scheduled for 1994 had been endorsed by the General Assembly in its resolution 48/39 of 10 December 1993. The Subcommittee recommended to COPUOS, for its approval, the activities scheduled for 1994 under the regular budget, and took note of other activities of the Programme, all of which are to be implemented as part of the space-applications-related recommendations of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82), as proposed by the Expert on Space Applications in his annual report (A/AC.105/555) submitted to the Scientific and Technical Subcommittee at its 1994 session.

I. MANDATE OF THE PROGRAMME

2. The General Assembly, in its resolution 37/90 of 10 December 1982, took into account the recommendations of UNISPACE 82, and expanded the mandate of the Programme to include, in particular, the following elements: (a) provision of assistance in the development of indigenous capability at the local level; (b) provision of long-range fellowships for in-depth training; (c) provision of technical advisory services to Member States and regional institutions upon request; (d) organization of regional and international training courses, seminars, workshops, conferences and technical expert meetings for the benefit of specialists, educators, managers and decision makers in order to enhance their technical capabilities as well as keep them abreast of ongoing developments in the discipline; (e) acquisition and dissemination of space-related information; and (f) promotion of greater cooperation between developed and developing countries, as well as among developing countries. Presented below are summaries of the activities carried out in 1994, those scheduled for implementation in 1995 and those proposed for 1996.

A. Development of indigenous capability

3. The latest efforts of the Programme in assisting the developing countries in building up indigenous capabilities in space science and technology are being channelled towards the development and enhancement of knowledge and skills in the discipline by the establishment and operation of centres for space science and technology education at the regional level. A prerequisite to successful space technology applications is the building up of various essential indigenous capacities, particularly human resources, within each region. Specifically, if effective assimilation and appropriate application of space technology are to succeed in the developing countries, and particularly if such a discipline as remote sensing is to transcend its current image of being a technology-driven tool into a user-driven one, efforts must be devoted, at the local level, to the development of necessary high-level knowledge and expertise in space technology fields. In recognition of such a prerequisite, the General Assembly, in its resolution 45/72 of 11 December 1990, endorsed the recommendation of COPUOS that:

> "... the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort to establish regional centres for space science and technology education in existing national/regional educational institutions in the developing countries" (A/AC.105/456, annex II, para. 4 (n)).

4. A progress report (A/AC.105/498) on the establishment of the centres was prepared in early 1992. An updated project document (A/AC.105/534) on the same subject was issued in January 1993. A new report on the latest status of the centres will be issued in late 1995.

5. The activities at each Centre will be undertaken in two major phases. Phase 1, will emphasize the development and enhancement of the knowledge and skills of university educators and research and application scientists in both the physical and natural sciences as well as in analytical disciplines. This will be accomplished through rigorous theory, research, applications and field exercises over a nine-month period as laid out in the curriculum of the education programme of each Centre. Phase 2 will focus on ensuring that the participants make use of the skills and knowledge gained in phase 1 in their pilot projects, which are to be conducted over a one-year period in their own countries. The activities and opportunities provided in the two phases should adequately equip the participants (educators, and research and applications scientists) to introduce relevant aspects of space science and technology into existing education curricula in their own countries, and to contribute significantly to development programmes in their own countries. Each of the centres for space science and technology education should also contribute to the sustainable development of natural resources (air, water, land); provide a crucial supplementary input for biodiversity conservation and other related environmental programmes; and improve the overall development of the national technological base, including that of the telecommunications industry.

6. Each Centre's initial programmes will focus on remote sensing and geographic information systems, satellite meteorology, satellite communications, geo-positioning systems and atmospheric sciences. Its Data Management Unit will be linked to existing and future relevant global databases. Each Centre will also foster continuing education programmes for its graduates, and awareness programmes for policy and decision makers and the general public in each region. A master curriculum is now being developed, internationally, for these centres. These centres should result in the development and growth of capacities that will enable each of the participating developing countries to enhance its knowledge, understanding and experience in those aspects of space science and technology that have the potential for a greater impact on its economic and social development including the preservation of its environment.

7. A step-by-step implementation of the programme of each Centre in education, research and applications as laid out in the two phases described above and in its academic curricula should have a multiplying effect and should result in the following:

(a) A capacity for each country to enhance its scientific and technical knowledge and experience particularly in those application areas (Earth observation and telecommunications) that have the potential for a greater impact on each country's economic and social development, including the preservation of its environment;

(b) A capacity to utilize data from Earth observation systems for weather prediction and monitoring of hurricanes and other natural phenomena so that appropriate disaster management and mitigation programmes can be undertaken;

(c) A capacity to strengthen institutions of higher education as well as national and regional institutions, and subsequently to enable each country to support research and development efforts in those national institutions, especially those dealing with the understanding and application of environmental information systems;

(d) A capacity for each country to enhance national and regional communication systems, including those associated with rural development, delivery of health services, disaster mitigation, air and maritime navigation, and to establish a network linking the region's professionals and scientists, government establishments and industries, in order to facilitate the exchange of ideas, data and experience;

(e) A capacity to develop appropriate environmental and atmospheric sciences curricula that can be easily taught and demonstrated at the high-school and university level in each country, and to effectively prepare educators to teach classes in those disciplines on their return to their institutions;

(f) A capacity to participate in regional and international environmental programmes such as the International Geosphere-Biosphere Programme and Mission to Planet Earth, and to contribute to the understanding and support of international actions on such issues as global warming and climate change, ozone layer depletion, global deforestation, land degradation and management of the coastal marine environment.

8. The first step in the establishment of the centres is the assessment, through evaluation missions, of the facilities and the resources that would support the programmes of the centres. The progress, to date, in establishing a centre at each regional level is described below.

Location of centres

9. Latin America and the Caribbean: On the basis of the report of the evaluation mission to Latin America and the Caribbean, the Office for Outer Space Affairs identified Brazil and Mexico as the most viable locations where two arms of the regional Centre for Space Science and Technology Education could be established. The Governments of Brazil and Mexico, with input from the United Nations, are finalizing the legal status and the conditions under which the regional Centre for Space Science and Technology Education for Latin America and the Caribbean will operate.

10. Asia and the Pacific: From 8 to 29 May 1994, an evaluation mission visited China, India, Malaysia, Pakistan, Sri Lanka and Thailand to assess and analyse the elements offered by these countries. These elements included the physical infrastructure (i.e. academic, research and living facilities), financial support, equipment available on a dedicated or shared basis, existing space technology-related education programmes and experience, the degree to which the proposed concept of a centre could be fulfilled, governmental and institutional support, existing/planned communications systems, administrative and academic autonomy offered to the Centre, local expertise and experience available to the Centre.

11. The Office for Outer Space Affairs analysed the final report of the Evaluation Mission to these six countries. Beginning as a single node in India, the Centre for Space Science and Technology Education in Asia and the Pacific should subsequently grow as a network institution with major nodes to cover specific programme elements in established space-technology related institutions in the region. The Centre should allow for its growth to countries with established and potential capabilities, as well as to countries which already have or might develop viable programmes in selected areas of space science and technology. The complete text of the Statement of the Office for Outer Space Affairs on the establishment and location of the Centre in Asia and the Pacific is shown in annex I.

12. An evaluation mission to the Islamic Republic of Iran was conducted in August 1993. The results of the mission have been forwarded to the Government of the Islamic Republic of Iran for its attention and necessary follow-up action. Negotiations are continuing with the Government on the establishment of this Centre.

13. Africa: Evaluation missions to Africa (Ghana, Kenya, Morocco, Nigeria, Senegal and Zimbabwe) were conducted in 1993. All the Governments concerned have offered their comments on the reports of the missions. An analysis of the mission reports by a group of experts is now in progress.

14. Western Asia: The evaluation mission to Egypt, Jordan and the Syrian Arab Republic was conducted from 16 to 26 March 1994. Negotiations are in progress with concerned parties on the establishment of this Centre.

15. The centres in (a) Asia and the Pacific, and (b) Latin America and the Caribbean will be inaugurated in 1995. In each case, the Governing Board will be the principal policy-making organ of each Centre.

B. Long-term fellowship programmes for in-depth training

16. The Programme received 19 long-term fellowship offers for the 1993-1994 period from the Governments of Brazil (10) and China (4), as well as from the European Space Agency (ESA) (5). For the 1994-1995 period, the Programme received 17 long-term fellowship offers from the Governments of Brazil (10) and China (2) and ESA (5). The status of the 1994-1995 awards is reflected in annex II of the present report. The fellowship awards cover monthly allowances for room and board, books, local travel and health benefits. The offers are described below in further detail.

17. The 10 long-term fellowships offered by the Government of Brazil are for research and applications in remote sensing technology and are tenable at the Instituto Nacional de Pesquisas Espaciais (iNPE), Sao José dos Campos, Brazil. The ninth set of participants in this fellowship series were selected from the region of the Economic and Social Commission for Latin America and the Caribbean (ECLAC) and commenced their studies in April 1994; these studies were completed at INPE on 4 November 1994. The next set of participants will commence their studies in April 1995.

18. The two fellowships offered by the Government of China, each for a period of one year, are for research and training in geodesy, photogrammetry and remote sensing. These fellowships are tenable at the Wuhan Technical University of Surveying and Mapping, Wuhan, China, and the 1994/95 participants began their studies in October 1994.

19. The five ESA long-term fellowships are each for a period of one year of research and study at ESA institutions and in the disciplines described below:

(a) Space antennas and propagation (1): European Space Research and Technology Centre, Noordwijk, the Netherlands;

(b) Communications systems (1): European Space Research and Technology Centre, Noordwijk, the Netherlands;

(c) Remote sensing information systems (2): European Space Research Institute, Frascati, Italy;

(d) Remote sensing instrumentation (1): European Space Research and Technology Centre, Noordwijk, the Netherlands.

20. The 1995/96 fellowship awards were advertised in December 1994. Selected candidates will begin their studies on 4 September 1995 at the above-mentioned institutions of ESA.

C. Technical advisory services

21. The United Nations Space Applications Programme is now entering an intensive and extensive phase of technical advisory service. The latter is fuelled by four factors:

(a) The developmental support needed by the centres for space science and technology education that are being established;

(b) Advances in Earth Observation Systems technology particularly in microwave remote sensing and the need to prepare Member States for this new phase of Earth observation;

(c) Follow-up projects that have resulted from different activities of the Programme;

(d) Increasing requests for the services of the Programme by national and regional entities.

22. The following are among the technical advisory services currently being rendered under the auspices of the Programme.

1. Republic of Korea: Asia-Pacific Satellite Communications Council

23. In 1992, the Government of the Republic of Korea hosted and co-sponsored the United Nations Workshop for Communications and Development at Seoul from 24 to 28 November. The main objectives of this Workshop were to exchange information on the status and future trends of satellite communications technology, to assess its contributions to economic and social development in this region, and to provide a forum that could enhance regional and international cooperation particularly in the fields of communications. One of the major outcomes of that Workshop was the endorsement of the initiative of the Republic of Korea to establish an Asia-Pacific Satellite Communications Council (APSCC) as a forum that could accomplish the objectives of that Workshop. In the view of the participants at that Workshop, such a Council is vital for the coordination and implementation of satellite communications programmes to meet the growing demands for such services in the Asia-Pacific region.

24. According to the 1992 Workshop participants, among the compelling reasons, which are peculiar to Asia and the Pacific, for establishing APSCC were the following:

(a) There is a rapid increase in the number of satellite communications users and in the number of countries that already own or are planning to acquire the space segment of a satellite communications system. An APSCC is needed to promote cooperation and harmonization in satellite communications development in the region;

(b) Many countries of the region are made up of islands that are scattered, particularly over the Pacific Ocean. Communications among and within these islands can only be effectively achieved through a satellite communications network. An APSCC is needed to promote the gaining of access to information by and of such island States, and to provide for better cooperation in the region;

(c) Because they are heavily dominated by terrestrial operators, existing communications-related institutions within the region do not consider space communications as their primary concern. According to the 1992 Workshop participants, such institutions have not manifested much interest in such important issues as education, health care and welfare (information on these issues are routinely transmitted today via satellites), and that these institutions/organizations are mostly interested in technical and business aspects of telecommunications. An APSCC is needed to bridge these gaps.

25. In 1992, an Ad Hoc Committee was established to draft the Constitution and associated by-laws and procedures of the Council. The Government of the Republic of Korea offered to host the APSCC secretariat as well as provide necessary funds for its operation. By 1 May 1993, 20 Asia-Pacific countries agreed with the views of the 1992 Workshop participants and communicated to the United Nations their approval of the establishment of the Asia-Pacific Satellite Communications Council. In a letter dated 1 March 1993, the Secretary-General of International Telecommunications Union (ITU) indicated that such a Council could be a useful vehicle for continuing exchange of information on proposals and plans for satellite communications in the region. He said that ITU would be pleased to cooperate in this initiative in appropriate ways.

26. The 1994 APSCC Workshop was held at Seoul from 26 to 29 October 1994 and co-sponsored by the Republic of Korea and the United Nations. At the Inauguration Meeting held on 25 October 1994, APSCC was formally inaugurated and its constitution adopted by consensus. All the officers of APSCC, including its President were also elected; and the offer of the Republic of Korea to host the secretariat of

APSCC was welcomed and accepted. The adopted constitution is being sent to all its member States and communication satellite operators in the region for endorsement. At the request of the 1992 Workshop, the United Nations Programme on Space Applications actively cooperated with the Ad Hoc Committee established at that time and assisted in the final establishment of APSCC. The 1994 APSCC Workshop was held under the theme "Towards a closer neighbourhood by satellite communications". It was attended by 228 satellite communications experts, government officials and private satellite operators from the Asia-Pacific region as well as from other regions.

27. The objectives of APSCC are as follows:

(a) To exchange views and ideas on technologies, systems, policies and services of satellite communications which are applicable to the betterment of the Asia-Pacific region;

(b) To promote and accelerate the efficient introduction of telecommunication services via satellites in the region;

(c) To assist in the development of national capabilities for establishing domestic and regional satellite communication services;

(d) To enhance the coordinated effort to formulate the recommendations of technical standards of satellite communications within the region.

Both the 1992 and 1994 Workshops were opened by the Minister of Communications of the Republic of Korea.

2. Ecuador: Cotopaxi ground receiving station

28. In 1993, the Programme on Space Applications concluded a mission to the Andean subregion in respect of the Cotopaxi ground receiving station (A/AC.105/555, paras. 23-27). On the basis of the mission report, the Corporación Andina de Fomento (CAF) approved a technical cooperation fund of US$200,000 to finance a feasibility study and other substantive actions necessary for the establishment of the Multi-National Enterprise within which the Cotopaxi station will operate. This feasibility study began in late 1994 and will be concluded in the first quarter of 1995. A decision on the results of this study will subsequently be taken by the Government of Ecuador and other members of the Andean group.

3. Chile: Follow-up to the Second Space Conference of the Americas

29. The Programme on Space Applications is providing support to and serving in the Technical Advisory Committee of the pro tempore secretariat created at the conclusion of the Second Space Conference of the Americas held at Santiago, Chile in 1993. In November/December 1994, the Programme served in a Technical Panel established by the pro tempore secretariat of the Conference to undertake a technical evaluation of the projects submitted by Governments and institutions of the region, in response to the recommendations of the Conference. The Panel screened, analysed, integrated and consolidated these project proposals on the basis of their technical merits and reformulated them in accordance with project submission formats of Governments and funding institutions.

4. Africa: Implementation of the recommendation of the Dakar Regional Conference

30. As a follow-up to the 1993 Regional Conference on Space Technology for Sustainable Development in Africa, which was held under the auspices of the Programme, the Office for Outer Space Affairs communicated the report of that Conference to all the entities concerned. The United Nations Development

Programme (UNDP) subsequently confirmed its willingness to cooperate with the United Nations Office for Outer Space Affairs in implementing one of the major recommendations of the Conference, i.e. to urgently establish an efficient communication network/linkage among African professionals and scientists at national, subregional/continental levels.

31. In December 1993, as an activity of the Programme, the United Nations Office for Outer Space Affairs submitted a project proposal that could address the above-mentioned recommendation of the Conference to the UNDP for its consideration and support. The Association of African Universities welcomed this initiative, which falls within its Core Programme and which will be among the perspectives to be addressed at its Colloquium in January 1995.

32. A successful funding campaign for this purpose will result in the participation of nine universities in nine African countries and three universities in three European countries in its activities and will enable them to benefit from the space segment already proposed for the Mercure project of the United Nations Environment Programme (UNEP), i.e. a transponder of INTELSAT VII. The minimum requirement for participation by each of these universities is an Earth station, with receive and transmit capabilities, and with a minimum throughput capacity of 19.2 kilobytes per second. Such a capacity would allow these stations to transmit and receive electronic mail and computer files from existing databases, and to communicate among themselves. Each participating African institution would also need to have an adequate workstation for the processing of the data it will gain access to.

33. If the above-mentioned project proves successful, similar pilot projects could be initiated in other developing countries of Asia and the Pacific, Latin America and the Caribbean as well as in Western Asia.

5. Frascati Training Course: Follow-up activities

34. In 1993, the United Nations, Office for Outer Space Affairs, Space Applications Programme and Department for Development Support and Management Services, and ESA jointly initiated, on request, a technical assistance programme that would strengthen the capability of a number of institutions in Africa and Latin America.

35. The United Nations/European Space Agency selected projects that are ongoing but are in need of assistance in the following specific areas, as follows:

(a) Satellite data that are required by the project concerned;

(b) Specialized on-the-job training, by making use of the satellite data provided to the project;

(c) Hardware components and/or software packages necessary to complete the processing configuration for the required data handling and manipulation;

(d) Tools to connect to an E-mail network for exchange of technical information and updating on results and problems;

(e) Thematic seminars as meeting opportunities for project experts to technically discuss specific results and/or problems associated with the project implementation;

(f) Technical assistance and documentation on the above areas.

36. Several application projects, though at different technical and maturity levels, have already been sent to the United Nations and ESA by the participants at the two previous United Nations/European Space

Agency training courses held at the European Space Research Institute (ESRIN) of ESA on the use of ERS-1 data. These first submissions from Latin America are now being used by the United Nations and ESA to formulate an integrated set of thematic regional programmes.

D. United Nations training courses, workshops, conferences and symposia

1. Activities carried out in 1994

37. In 1994, the United Nations conducted two training courses, five workshops and one symposium under the auspices of the Programme. A summary of each of these activities is presented below.

Frascati, Italy: United Nations/European Space Agency Training Course for Latin American and Caribbean Countries on Applications of the European Remote Sensing Satellite (ERS-1) Data for Natural Resources, Renewable Energy and the Environment

38. The United Nations/European Space Agency Training Course for Latin American and Caribbean Countries on Applications of the European Remote Sensing Satellite (ERS-1) Data for Natural Resources, Renewable Energy and the Environment was organized by the Programme on Space Applications and by the Department for Development Support and Management Services in cooperation with ESA. It was held from 18 to 28 April 1994 at ESRIN at Frascati, Italy. The final session and closing ceremony of the Course were held at the Headquarters of the Istituto Italiano-Latino Americano at Rome on 29 April 1994.

39. The objectives of the Course were (a) to provide participants from Latin American countries with a theoretical basis and practical experience in various aspects of microwave remote sensing, focusing on the applications of that technology to natural resources, sources of renewable energy and, in particular, its use in conducting inventories and monitoring the environment; and (b) to familiarize the participants with the bibliography and archive of ERS-1 materials and data that are available at the ESRIN facility at Frascati.

40. The Course was attended by 24 participants from the following countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela. Financial support to defray the cost of air travel and living expenses of the participants was provided by the United Nations Trust Fund for New and Renewable Sources of Energy. The programme for the Course was developed jointly by ESA and the United Nations (Office for Outer Space Affairs). The lecturers for the course came from France, Spain, ESA and the United Nations.

41. The Course provided participants with the physical theory on which remote sensing, both active and passive, is based. The Course presented an overall view of remote sensing in various intervals of the electromagnetic spectrum, including the visible, infrared and microwave regions of the spectrum. Regarding microwave remote sensing, the Course included the theory and concepts of Synthetic Aperture Radar image formation as well as an introduction to digital image processing of radar data in agricultural, oceanographic, geologic, topographic and cartographic applications. The Course also provided the participants with examples of the applications of the data received from various instruments on board ERS-1 as well as with hands-on experience in digital processing of its images. The presentations made by the lecturers, and a number of participants, included case-studies of programmes or projects conducted in Africa.

42. Opportunities were provided for the participants to make short presentations on the research or operational work that they were conducting at their home institutions. During discussion periods regarding their work and experiences, the participants indicated that two obstacles to their utilization of images such as those that they were learning to use at the course were the lack of access to them and a need for further education on the principles of their use and hands-on training to develop experience in the mechanics of their

analysis. The representatives of the United Nations and ESA indicated that they were exploring ways and means by which at least a limited amount of data and further training could be provided for use in their ongoing activities. The report on the Course is contained in document A/AC.105/594.

Stockholm and Kiruna, Sweden: Fourth United Nations Training Course on Remote Sensing Education for Educators

43. The Fourth United Nations Training Course on Remote Sensing Education for Educators was organized in cooperation with the Government of Sweden through the Swedish Board for Investment and Technical Support (BITS) and was hosted by the Department of Physical Geography, Stockholm University, and the Swedish Space Corporation (SSC Satellitbild), Kiruna, for the benefit of developing countries. It was held at Stockholm and Kiruna from 2 May to 10 June 1994.

44. The main objectives of the Course were to provide participants with educational and practical knowledge on current and future remote sensing systems, including the acquisition, processing, interpretation, application and archiving of the data generated by such systems, to demonstrate different satellite remote sensing methods, to expose the participants to various aspects of application of satellite data, including data and materials from the participants' own countries, in project planning and management, as well as to equip them with the ability to introduce elements of the technology and its applications, as appropriate, in the educational curricula in their universities and institutes. The programme of the Course was designed jointly by the Office for Outer Space Affairs, Stockholm University and SSC Satellitbild.

45. The Government of Sweden, through the University of Stockholm, SSC Satellitbild and BITS, coordinated local arrangements and provided technical equipment, materials, course facilities, local transportation and the course instructors. Funds allocated by the United Nations were used to defray the costs of international air travel for 11 participants. On behalf of the Government of Sweden, BITS provided room and board, local transportation and an allowance for incidental expenses for all the participants as well as international air travel for 16 participants.

46. Participants at the Course totalled 27 educators; they came from Bangladesh, Colombia, Costa Rica, Guyana, Jamaica, Jordan, Kenya, Morocco, Namibia, Nepal, Nigeria, Pakistan, Palestine, Panama, Peru, Sri Lanka, Swaziland, United Republic of Tanzania, Tunisia, Uganda, Uruguay, Viet Nam, Yemen and Zimbabwe. In addition to the Swedish instructors, experts from Germany, Norway and ESA provided instructions at the Course. The report on the Course is contained in document A/AC.105/581.

Cairo, Egypt: Fourth United Nations/European Space Agency Workshop on Basic Space Science

47. The Fourth United Nations/European Space Agency Workshop on Basic Space Science was hosted by the Government of Egypt and held at Cairo, Egypt, from 27 June to 1 July 1994. The Workshop was co-sponsored and co-organized by ESA, The Planetary Society (TPS) and the United Nations.

48. Because the scientific, economic and social progress of any country are strongly interrelated, and because basic space science, including physical and mathematical sciences, plays an important role in providing solutions to problems of development in general, this Workshop was organized to call the attention to the fact that the pursuit of basic space science is critical to the future economic prosperity of all countries. The Workshop focused on: (a) creating and improving awareness among scientists of current and future scientific and technical aspects of basic space science; (b) enhancing national capabilities that could be used to develop programmes and to undertake research activities in basic space science; (c) enhancing scientific cooperation internationally and, in particular, among developing countries; (d) addressing the question of effectively integrating basic space science into the programmes of the planned centres for space science and technology education; and (e) exploring avenues of education, training and research on subjects in basic space science.

Workshop sessions included topics related to planetary science, the Sun, ground-based and space-based astronomical observatories, and space astronomy and astrophysics.

49. The Workshop was attended by 95 scientists from 22 countries: Austria, Bahrain, Canada, China, Colombia, Costa Rica, Egypt, Germany, Honduras, India, Japan, Kenya, Mauritius, Mozambique, New Zealand, Nigeria, Oman, South Africa, Spain, United States of America, Zaire and Zambia; and the following 7 national and international organizations: Austrian Space Agency, ESA, German Space Agency (DARA), International Centre for Theoretical Physics, National and Aeronautics and Space Administration (NASA) of the United States of America, TPS and the United Nations. Funds allocated by these organizations were used to cover the cost of international air travel and daily subsistence allowance for 28 participants from 15 countries. The Government of Egypt provided the Workshop facilities and local transportation for the duration of the Workshop, and room and board for a number of participants. The report of the Workshop is contained in document A/AC.105/555.

Beijing, China: United Nations/China/European Space Agency Workshop on Microwave Remote Sensing Applications

50. The United Nations/China/European Space Agency Workshop on Microwave Remote Sensing Applications was organized in cooperation with the Government of China and hosted by the State Science and Technology Commission of China (SSTCC) and its National Remote Sensing Centre, from 14 to 18 September 1994, for the benefit of participants particularly from Asia and the Pacific.

51. The objective of the Workshop was to expose the participants to various aspects of current and future microwave remote sensing systems and applications of radar data to natural resources exploration and environmental monitoring. The experiences and programmes of a number of countries, including those particularly from Asia and the Pacific, in the development and applications of microwave remote sensing, were featured. The Workshop concluded with working group deliberations that focused on three major areas related to (a) data availability and accessibility; (b) practical applications of radar data; and (c) required education and training. The observations and recommendations of these working groups are contained in the report of the Workshop.

52. The participants were professionals with several years of experience in remote sensing or in developing plans for the management of natural resources and related programmes that can benefit from the applications of microwave remote sensing. The Workshop was attended by 85 participants from the following countries/territories and international organizations: Bangladesh, Cambodia, Canada, China, Germany, Hong Kong, India, Indonesia, Japan, Malaysia, Myanmar, Philippines, Republic of Korea, Singapore, Sri Lanka, Thailand, United Kingdom of Great Britain and Northern Ireland, United States; ESA, United Nations (Office for Outer Space Affairs) and UNDP (Beijing Office). Funds allocated by the United Nations and ESA for the organization of the Workshop were used to defray the cost of international air travel and daily subsistence allowance of 16 participants. The Government of China, through SSTCC, provided room and board for these same participants, as well as conference facilities and local transportation for all participants. A detailed report on the Workshop is contained in document A/AC.105/588.

Lima, Peru: United Nations/European Space Agency Workshop on Global Change and the Training Course on Microwave Remote Sensing Applications

53. The United Nations/European Space Agency Workshop on Global Change and the Training Course on Microwave Remote Sensing Applications were organized in cooperation with the Government of Peru for the benefit of participants from the ECLAC region. These activities were co-sponsored by ESA and by the

Comisión Nacional de Investigación y Desarrollo Aeroespacial (CONIDA) and were held consecutively from 3 to 4 and from 5 to 14 October 1994, respectively, at the Headquarters of CONIDA in Lima.

54. The objectives of the Workshop were (a) to familiarize participants with the scope of Global Change and with the location, contents and conditions of access to its archives in the region and internationally and (b) to discuss ways which would enable them to contribute to the data collection efforts as well as to utilize data from the archives being integrated in the Latin American and Caribbean region. Through presentations at the Workshop, the participants became aware that the International Geosphere-Biosphere Programme, also known as Global Change, aims at understanding the Earth as a complete system, in particular the interactions between land, ocean and atmosphere and the effects that changes in any of the biophysical or geophysical parameters ca . have on the system. Through round-table discussions, the participants and instructors identified international cooperative activities, including some in Latin America and the Caribbean, that are being conducted to establish worldwide archives of data from satellite and land-based sources.

55. The Course provided participants with education on the physical basis for radar (microwave) remote sensing as well as opportunities for hands-on training in specific applications of radar data. In particular, the participants became familiar with a new generation of sensor systems, specifically the radar satellites, which have the capability of gathering Earth observation data through cloud cover making them the best source of data over the tropical regions. Through theoretical and practical exercises, the participants acquired knowledge regarding the information that can be derived from these data and how this information can contribute significantly to the knowledge of the natural resources of a country and assist in the formulation of sustainable development and management policies.

56. Funds provided by the United Nations and ESA were used to defray the costs of air travel as well as a daily subsistence allowance for 21 participants and instructors in the Workshop and Training Course. The Workshop and Training Course were attended by 24 participants from the following countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Panama, Peru, Uruguay and Venezuela. The instructors for the Workshop and the Course came from Argentina, Brazil, Canada and Costa Rica; and from ESA and the United Nations (Office for Outer Space Affairs). A detailed report on the Workshop and Course is contained in document A/AC.105/596.

Graz, Austria: Enhancing Social, Economic and Environmental Security through Space Technology

57. The United Nations and the Government of Austria jointly organized a Workshop on "Enhancing Social, Economic and Environmental Security through Space Technology". This Workshop was held from 12 to 15 September 1994 at Graz and was hosted by the Austrian Federal Ministry for Foreign Affairs, co-sponsored by the state of Styria, the City of Graz and ESA.

58. The objective of the Workshop was to show that space technology can be a powerful tool for accelerating national development and that it provides a way of overcoming obsolete technologies and an alternative to percolation and trickle-down models of national development. Participants in this Workshop were expected to apply the experience gained at the Workshop to projects and report to appropriate authorities in their home countries.

59. Presentations focused on the applications of space technology for improving life on Earth while protecting the environment. The theme of the meeting built upon the Agenda 21[1] of the United Nations Conference on the Environment and Development (UNCED), held at Rio de Janeiro in June 1992, and its recommendations for sustainable development. Through technical presentations and working group discussions, the Workshop participants addressed the issues of how best to safeguard the environment and to ensure the efficient management and sustainable development of natural resources.

60. The participants were senior technical personnel in decision-making positions who were actively engaged in projects dealing with satellite communications or Earth observations. The following Member States and international organizations were represented at the Workshop: Argentina, Bangladesh, Bhutan, Brazil, Cameroon, Cape Verde, Cambodia, China, Costa Rica, India, Indonesia, Iran (Islamic Republic of), Mongolia, Pakistan, Republic of Korea, Senegal, Sri Lanka, Syrian Arab Republic, Tunisia, Uganda, Uruguay; ESA, International Mobile Satellite Organization (Inmarsat) and the United Nations Office for Outer Space Affairs. Contributors to the deliberations of the Workshop from Austria, France, Germany, Italy, Netherlands, Russian Federation, United Kingdom and the United States also participated. The report on the Workshop is contained in document A/AC.105/586.

Jerusalem, Israel: Benefits of Space Technology for the Developing World - from Economic Growth to Environmental Protection

61. The Symposium on "Benefits of Space Technology for the Developing World - from Economic Growth to Environmental Protection" was the fourth in a series organized by the United Nations and the International Astronautical Federation (IAF) and was held in conjunction with the 45th IAF Congress in Jerusalem. ESA and the Commission of the European Communities (CEC) co-sponsored the Symposium, which was hosted by the Israeli National Committee on Space Research (NRSC), on behalf of the Government of Israel.

62. The objective of the Symposium was to present well-established models of space applications and to develop, through working group discussions, general principles on how developing countries can successfully use space technologies, including remote sensing and space communications systems, for environmental protection and for economic and social development.

63. The programme of the Symposium was designed to provide the participants, through plenary presentations, with knowledge about the various efforts that were being undertaken at the national and international levels to provide access for the developing countries to new technologies. The main emphasis of the presentations was to highlight general principles on how developing countries could successfully use space technologies, including remote sensing and space communication systems, for environmental protection and for economic and social development.

64. The following Member Sates and intergovernmental and international organizations were represented at the Symposium: Brazil, Cameroon, China, Costa Rica, Egypt, India, Mexico, Philippines, Republic of Korea, Senegal, Thailand, Uruguay; ESA, CEC, IAF, Inmarsat, ITU and United Nations Office for Outer Space Affairs. Participants also came from Austria, Canada, Czech Republic, France, Ireland, Israel, Netherlands, Spain, United Kingdom and United States also attended. The report of the Symposium is contained in document A/AC.105/589.

2. Activities scheduled for implementation in 1995

65. The training courses, workshops, and symposia scheduled for 1995 are shown in annex III.

3. Activities proposed for implementation in 1996

66. The following training courses and conferences are proposed for 1996:

(a) Sixth United Nations/Sweden International Training Course on Remote Sensing Education for Educators;

(b) Second United Nations Regional Conference on Space Technology for Sustainable Development in Africa;

(c) Sixth United Nations/European Space Agency Workshop on Basic Space Science;

(d) Second United Nations Workshop on Spin-off Benefits of Space Exploration;

(e) United Nations/European Space Agency International Microwave Remote Sensing Training Course;

(f) Second Workshop on Payloads on Small Satellites;

(g) United Nations International Training Course on Communications Technology for Development;

(h) United Nations Workshop on Radar Remote Sensing Applications.

67. The actual implementation of the above-mentioned activities may be affected by the decision of the General Assembly on the organization of a third United Nations Conference on the Exploration and Peaceful Uses of Outer Space. The decision of the Assembly on such a conference may also have an impact on an International Youth Forum on Space Technology and our Future, which is being planned for the 1996-1997 period.

E. Space information

68. The directory on Education, Training, Research and Fellowship Opportunities in Space Science and Technology and its Applications was updated and reissued in 1993 as document A/AC.105/548. The 1995 edition of Seminars of the United Nations Programme on Space Applications, the sixth in the series of selected papers from the activities of the Programme, was issued as document A/AC.105/584.

F. Promotion of greater cooperation in space science and technology

69. Most of the activities covered in the present report have clearly advanced regional cooperation in space science and technology. Those noted below are noteworthy.

70. The association of the Programme with Secretariat units and specialized agencies of the United Nations, particularly UNEP, the United Nations Educational, Scientific and Cultural Organization (UNESCO), Food and Agriculture Organization of the United Nations (FAO), ITU and World Meteorological Organization (WMO), as well as with intergovernmental organizations, such as ESA, INTELSAT and Inmarsat, and with a number of non-governmental organizations, such as the Committee on Space Research of the International Council of Scientific Unions, IAF, International Society for Photogrammetry and Remote Sensing (ISPRS) and TPS, is advancing cooperation between developed and developing countries, as well as among the developing countries.

71. The efforts of the Programme to establish the centres for space science and technology education will also reinforce regional cooperation, particularly among developing countries, and between developed and developing countries.

II. VOLUNTARY CONTRIBUTIONS

72. The successful implementation of the 1994 activities of the Programme benefited from the support and voluntary contributions of States Members of the United Nations and their institutions, as well as from the assistance and cooperation of regional and international governmental and non-governmental organizations.

In 1994, the Programme received voluntary contributions, both in money and in kind, including the sponsorship of technical and scientific presentations by several experts, as detailed below:

(a) A number of Member States (Australia, Austria, Brazil, Canada, China, Egypt, France, Germany, Italy, Japan, Pakistan, Peru, Republic of Korea, Singapore, Spain, Sweden, United Kingdom, United States) provided support for the activities of the Programme in 1994 in various ways, including the following:

(i) Defrayal of the local expenses of candidates from developing countries in the long-term fellowship programmes (see paras. 16-20 and annex II);

(ii) Voluntary cash contributions were received in 1994 from the Governments of Austria (US$20,000) and Pakistan (US$10,000) in support of the activities of the Programme and from the United States (US$30,000) in support of the 1995 Workshop on Spin-off Benefits of Space Technology;

(iii) Co-sponsorship of the activities of the Programme and, in particular, the defrayal of the costs of participants' international air travel, local organization and facilities, room and board, and local transportation (see paras. 38-64);

(iv) Sponsorship (travel and daily subsistence allowance) of experts from Member States to provide technical presentations and to take part in deliberations of the activities of the Programme (see paras. 40, 46, 49, 52, 56, 59 and 63);

(v) Funding of experts (Australia and France) to participate in the evaluation mission to six Asia and Pacific countries in order to provide an accurate and informative report that could assist in the establishment of the centre for space science and technology education in that region;

(b) ESA support took the following forms:

(i) Defrayal of the local expenses of candidates from developing countries in its long-term fellowship programmes (see paras. 19-20 and annex II);

(ii) A financial contribution of US$95,000 in support of the workshops, training courses and conferences held at Cairo, Beijing, Jerusalem and Lima.

III. FINANCIAL PROVISIONS AND ADMINISTRATION OF 1995 ACTIVITIES

73. The 1995 activities of the Programme presented in this report will be implemented as follows:

(a) Financial provisions: Under the United Nations regular budget, a sum of US$443,000 was approved by the General Assembly at its forty-seventh session for implementing the activities of the Programme during the 1994-1995 biennium. In order to effectively carry out the mandated and expanded activities of the Programme, it has become necessary for the Programme to solicit additional funds, in the form of voluntary contributions, in support of its activities. These contributions will be used to supplement the regular budget of the Programme;

(b) Administration by and contributions and participation of staff: The Office for Outer Space Affairs, and in particular the Expert on Space Applications and his staff, will carry out the activities described in the present report. In this connection, travel will be undertaken as appropriate by the Expert and his staff under

the provisions of the biennium travel budget of the Office as approved by the General Assembly at its forty-ninth session and as may be necessary from voluntary contributions;

(c) Consultations, instructors, speakers and technical materials: Up to 50 specialists (necessitated, in particular, by the preparatory work associated with the establishment and operation of the regional centres for space science and technology education) in space science and technology and its applications will be required to serve as instructors, speakers and consultants during the implementation of the 1995 activities of the Programme. Expenses incurred in respect of the travel and per diem of these specialists and for necessary technical materials will be met partly from the regular budget and partly from voluntary contributions received from Member States and international organizations.

IV. SUMMARY OF STATISTICS ON SELECTED ACTIVITIES OF THE UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS FOR THE PERIOD 1983-1991

74. At the start of each activity of the United Nations Programme on Space Applications, the representatives of the Office for Outer Space Affairs, as a matter of practice, usually urge participants to communicate regularly with the Office as well as with the co-sponsors of each activity, in order to assess the effectiveness of each activity and subsequently improve the programme of the activity concerned. In particular, the United Nations and co-sponsors of the activities of the Programme are interested in the impact of the activity on the performance and productivity of the participant in his or her country. To this end, a survey of those who participated in the activities of the Programme in the period 1983-1991 was carried out. The results of the analysis of the information received as feedback from the participants are presented below.

75. In the period 1983-1991, the activities of the Programme included 13 workshops, 5 seminars, 21 training courses and 9 expert meetings covering topics in the field of space science and technology.

76. A total of 461 participants, out of 1,203 that took part in the activities, responded to the questionnaire. The professional activities of the 461 participants are diverse, covering various fields in remote sensing (mapping, agriculture, forestry, hydrology, geology, mineralogy, fisheries), environmental science and applications (climate and hydrological systems, bio-geochemistry and geophysics, ecosystem dynamics and bio-chemistry cycles, atmospheric chemistry, solid earth science) and basic space science (atmospheric research, planetary sciences, astronomy, cosmology).

77. Statistics on the number of participants who expressed the view that their involvement in the activities of the Programme had enabled them to initiate, establish or direct the different groups, facilities or activities in their different professional fields in their countries of origin are presented in the table below.

Summary of activities of participants in activities of the United Nations Programme on Space Applications (1983-1991)

Activity or facility	Initiation	Establishment	Direction involved
	(Number of participants)		
Study group	72	37	50
Coordination of user group	42	33	41
National committee	34	20	43
National programme	57	40	47
Regional and international cooperation	46	32	44
Data receiving station	29	14	25
Data analysis centre	37	28	41
Training facility	67	41	59
Total	384	245	350

The table shows quite significantly that an important number of the 461 participants surveyed were involved in both the establishment and management aspects of a variety of undertakings directly related to applications of space technology at some time after their participation in activities organized by the Space Applications Section. These aspects are considered critical in the long-term process of building indigenous capacity in space technologies which corresponds to the expanded mandate of the Programme.

Notes

[1]Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992 (United Nations publication, Sales No. E.93.I.8 and corrigenda), vol. I: Resolutions Adopted by the Conference, resolution 1, annex II.

Annex I

ESTABLISHMENT AND LOCATION OF THE REGIONAL CENTRE FOR SPACE SCIENCE AND TECHNOLOGY EDUCATION IN ASIA AND THE PACIFIC

Statement by the Office for Outer Space Affairs, United Nations

1. In response to the General Assembly's endorsement of the recommendation of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE 82) that the United Nations Programme on Space Applications should assist Member States in enhancing their indigenous capability at the local level, the Office for Outer Space Affairs developed a proposal for the establishment of Centres for Space Science and Technology Education in the developing countries. This proposal was presented to the Committee on the Peaceful Uses of Outer Space through its Scientific and Technical Subcommittee at their 1990 sessions. The objective of these centres is to enhance the capabilities of Member States in different areas of space science and technology, capabilities that can advance their social and economic development. Thus, each of the centres will pursue in-depth education, research and applications programmes with initial emphasis on remote sensing, satellite communications, satellite meteorology, geopositioning systems and atmospheric sciences.

2. On 11 December 1990, in its resolution 45/72, the General Assembly endorsed the Committee's recommendation that the United Nations should lead, with the active support of its specialized agencies and other international organizations, an international effort to establish regional centres for space science and technology education in existing national/regional educational institutions in the developing countries.

3. In May 1994, a United Nations evaluation mission visited the six countries which offered to host the Centre in Asia and the Pacific (China, India, Malaysia, Pakistan, Sri Lanka and Thailand). The mission reflected in its report a very high interest for hosting the Centre in each of the countries it visited as well as the universal belief that the Centre is very necessary for the development plans of the region. An analysis of the mission's report and of the proposals submitted by the six member States shows that the Centre could be established in five of the countries visited. The analysis also shows that these countries could be grouped into: (a) those where the existing infrastructure is not completely developed and where the presence of the Centre would serve to stimulate space-related technological development; and (b) those with a fully developed space technology capability in all areas and where the Centre could serve as a means of sharing the knowledge and experience of those countries with the rest of the region.

4. The concept of the Centre calls for it to offer the best possible education, research and applications experience to the participants in its programmes. Permanent and visiting staff from countries both within and outside the region would contribute to the attainment of these elements of the Centre programmes. However, in its first years, the Centre would need to draw substantively on the expertise and experience available at institutions in the host country. The countries with fully developed capabilities, both in the education process and in the development and use of space technology, would offer the Centre a stronger foundation and the greatest opportunity to accomplish the above-mentioned goals.

5. The Office for Outer Space Affairs organized an evaluation mission consisting of a team of experts who conducted a detailed analysis of the elements offered for the Centre by the six countries identified above (paragraph 3). These elements included the physical infrastructure (i.e. academic, research and living facilities), financial support, equipment available on a dedicated or shared basis, existing space technology-related education programmes and experience, the degree to which the proposed concept of the Centre could be fulfilled, governmental and institutional support, existing/planned communications systems, administrative and academic autonomy offered to the Centre local expertise and experience available to the Centre, and language (vis-à-vis the rest of the region).

6. The mission concluded that offers from most of the countries it visited were substantively and conceptually strong, with each offer having advantages in specific areas. In order to take advantage of the diversity of resources of all these countries, the Centre statutes should allow for full regional participation in its programmes. This would enable the Centre to manifest itself as a regional institution. After weighing the relative strengths and limitations of the offers to determine the best overall conditions that would enable the Centre to attain its objectives, it will be to the advantage of Asia and the Pacific that the Centre be established in one of the group of countries described in paragraph 3 (b) above, especially China or India. Such an arrangement (a) would enable the Centre to readily utilize existing capabilities, facilities and resources; and (b) would enhance the ability of the Centre to achieve successful results in a shorter-time period, thus building the confidence of the Centre in its ability to contribute to regional and international cooperation in space science and technology.

7. According to the report of the Evaluation Mission, the overall offers from both China and India in scientific, technical, institutional and governmental support are relatively similar. The advances and future directions of space science and technology in both countries would be major assets to the Centre as it advances to attain its objectives for the benefit of countries in Asia and the Pacific.

8. However, the offers and commitments made by India in its proposal to host the Centre favour an early establishment and operation of the Centre in Asia and the Pacific. Elements of these offers and commitments in India's proposal include (a) an end-to-end capability in space, ground and application segments (i.e. from theory, research, experiment, fieldwork, data application and packaging of results for decision-making in each specific discipline that matches the particular interest of each participant); (b) provision of all necessary financial and other resources for establishing, operating, and maintaining the Centre as envisaged by the United Nations; and (c) a commitment to work towards a full utilization of the appropriate capabilities and expertise in different countries of the region in order to ensure the effective operation of the Centre.

9. Beginning as a single node in India, the Centre for Space Science and Technology Education in Asia and the Pacific should subsequently grow as a network institution with major nodes to cover specific programme elements in established space-technology-related institutions in the region. The Centre should also allow for its growth to countries with established and potential capabilities, as well as to countries which already have or might develop viable programmes in selected areas of space science and technology.

10. Coordination of programmes of the Centre would be carried out by its Governing Board, which would be regional in composition. The Board would be the supreme decision-making body that determines and modifies the Centre's overall policy and adopts its academic programmes.

Annex II

LONG-RANGE FELLOWSHIPS OFFERED BY BRAZIL, CHINA AND THE EUROPEAN SPACE AGENCY WITHIN THE FRAMEWORK OF THE UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS, 1994-1995

Period	Country or organization	Subject	Financial support by host country or organization	Fellowships offered	Candidates selected	Applications submitted	User countries (one or more candidates selected)
1994/95	Brazil	Research and applications in remote sensing	Subsistence allowance and medical and accident insurance	10	1994 1995 Nominations in progress	1994 1995 Nominations in progress	1994 1995
1994/95	China	Geodesy, photogrammetry and remote sensing	Subsistence allowance and medical insurance	2	2	14	Sierra Leone Sudan
1994/95	ESA	Space antennas and propagation	Subsistence allowance	1	1994 No award 1995 Nominations in progress	1994 No award 1995 Nominations in progress	1994 No award 1995 Nominations in progress
1994/95	ESA	Remote sensing information	Subsistence allowance	1994 1 1995 2	1994 3 each for six months 2 each for 1 month 1995 Nominations in progress	Participation by ESA's direct invitation 1995 Nominations in progress	1994 Malaysia Indonesia Philippines 1995 Nominations in progress
1994/95	ESA	Communications system	Subsistence allowance	1	1994 No award 1995 Nominations in progress	1994 No award 1995 Nominations in progress	1994 No award 1995 Nominations in progress
1994/95	ESA	Remote sensing instrumentation	Subsistence allowance	1	1994 No award 1995 Nominations in progress	1994 No award 1995 Nominations in progress	1994 No award 1995 Nominations in progress

Annex III

UNITED NATIONS PROGRAMME ON SPACE APPLICATIONS: 1995 SCHEDULE OF COURSES, WORKSHOPS AND SYMPOSIA

Activities	Date and place	Objective	Status
Workshop on the development of education curricula for the Centres for Space Science and Technology Education	27 February-3 March 1995, Granada, Spain	To develop model curricula on Earth observation and environmental monitoring (remote sensing and GIS,[2] satellite meteorology), satellite communications and geopositioning systems and atmospheric sciences for the Centres on Space Science and Technology Education	Announcement on the Workshop already issued
United Nations/ESA International Microwave Remote Sensing Training Course on Applications of ERS-1 (for Asia and the Pacific participants)	28 April-5 May 1995, Frascati, Italy	To expose participants to the practical use of satellite radar imagery and disseminate information on accessibility to the environmental and natural resources management data	Confirmed Course already advertised globally
Fifth United Nations/Sweden International Training Course on Remote Sensing Education for Educators	1 May-9 June 1995, Stockholm, Sweden	To develop the knowledge and skills of university educators in remote sensing technology. The Workshop will also equip the participants with an ability to introduce element of the technology, as appropriate, in the academic curricula of their own universities and institutes	Confirmed Announcement on Workshop already issued
United Nations/ESA Training Course on the Use of ERS-1 Data for Mapping and Inventory of Natural Resources in Africa (for French-speaking countries)	15-19 May 1995, Libreville, Gabon	To expose participants to the practical use of satellite radar imagery and disseminate information on accessibility to the environmental and natural resources management data	Confirmed
United Nations/ESA Workshop on the Applications of Space Techniques to Prevent and Combat Disasters (for African English-speaking countries)	22-26 May 1995, Harare, Zimbabwe	To consider the ways in which developing countries can use space techniques to combat natural disasters and address the development of databases and the GIS to monitor disaster-related activities	Confirmed Announcement on Workshop already issued
United Nations/Spain/ESA International Workshop on Small Satellite Missions	19-23 Sept. 1995, Madrid, Spain	To focus on payloads in small experimental satellites, with emphasis on types and logistics of design process and system development methods that are associated with these satellites	Confirmed
United Nations/USA International Workshop on Spin-off Benefits of Space Technology: Challenges and Opportunities	16-20 Oct. 1995, USA	To address the many new dimensions that are continuously being introduced into Earth-based processes and procedures, including the enhancement of the scientific and technical capabilities made possible by space exploration and the opportunities for developing countries to participate in such efforts	Confirmed

[2]Geographical Information System.

Activities	Date and place	Objective	Status
United Nations Regional Conference on Space Technology for Sustainable Development in Latin America and the Caribbean in cooperation with ESA	30 Oct.-3 Nov. 1995, Mexico City, Mexico, in conjunction with SELPER Conference, 23-27 October 1995	To address the many new dimensions that are continuously being introduced into Earth-based processes and procedures, including the enhancement of scientific and technical capabilities made possible by space exploration and the opportunities for developing countries to participate in such efforts	Confirmed
United Nations/ESA Workshop on Basic Space Science (atmospheric sciences) to be organized for the benefit of Member States in Asia and the Pacific region	6-10 November 1995, Karachi, Pakistan	To address substantive and practical issues in atmospheric sciences, with emphasis on how the interactions that are taking place in the near, middle and upper atmospheres affect human activities on Earth	Confirmed
United Nations Workshop on the Use of Space Techniques for Monitoring and Control of Desert Environment for ESCWA region[b]	20-24 Nov. 1995, Damascus, Syrian Arab Republic	To focus on strengthening regional and global monitoring networks linked to the development of national monitoring systems for the observation of desert pollution, land degradation and desertification	Confirmed
United Nations/Austria/ESA Workshop on Benefits of Space Technology	4-7 September 1995, Graz, Austria	To focus on present and future derivations of space technology and their possible implementation and the use in the developing world	Confirmed
United Nations/CEC/ESA Workshop on Space Technology for the Developing World	29 Sept.-1 Oct. 1995, Oslo, Norway	To present the established models of space applications with the aim of developing through working group discussions general principles on how developing countries can successfully use space technologies, including remote sensing and space communications systems for environmental protection and for economic and social development	Confirmed

[b]Economic and Social Commission for West Asia.